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More meat, milk and fish by and for the poor

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Using the CLEANED approach to assess environmental impacts in the dairy value chain in Tanga, Tanzania

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Key messages

- The CLEANED approach was used to carry out a rapid, *ex-ante* assessment of different potential interventions to enhance Tanga district's dairy value chains.
- Productivity-enhancing interventions such as improved animal genetics, feed strategies and animal health, may increase annual milk production by 20,000 tonnes.
- This rise in production would, at current productivity levels, require an additional one hundred thousand hectares of land for feed and fodder production.
- The land cover and land use changes necessary to increase feed production could lead to negative effects on a range of ecosystem services in the district.
- At current productivity levels, increased livestock production will greatly increase local water use for feed production. Changing the feed 'basket' towards improved high dietary quality planted fodder will improve overall water use efficiency.
- Nutrient mining associated with livestock production in the mixed crop-livestock systems is likely to increase. To counter this, fertilizers or manure will be needed in greater quantities than at present.
- Clear win-wins in terms of reduced greenhouse gas emissions per produced milk quantity and increased milk production can be expected with the wide-scale adoption of the proposed productivity enhancing interventions.
- The CLEANED assessment indicates that the potential negative environmental impacts of increased livestock production can be minimized through (i) careful spatial planning, with e.g. protection of biodiversity hotspots, and (ii) introducing various efficiency measures, like increased yields of feed and fodder and better conversion efficiency at animal level. These can reduce the demand of land and water and the emissions of greenhouse gases.

The challenge

Livestock production makes multiple contributions to the economic and social well-being of the Tanzanian people. It provides income and highly nutritious food, it plays an important socio-cultural role, it is an asset for financial insurance and contributes to household livelihoods and resilience, it contributes to environmental resilience and sustainability by providing amendments for soil health and energy.

The gap between milk demand and local supply in Tanzania is very large and projected to continue to grow in the near to medium future. This unmet demand from consumers presents an important opportunity to improve the welfare of producers and market agents, through income and employment generated in dairy production, processing and marketing along the dairy value chain (VC).

The Livestock and Fish CGIAR Research Program – locally referred to as *Maziwa Zaidi* – has embarked on an effort to transform the Tanzania dairy value chain and to produce more milk by and for the poor. It envisages an inclusive and sustainable development of the smallholder dairy value chain over the coming decade.

Tanga district, comprising two main dairy production systems, has been the focus of the Program's interventions in Tanzania. About 30% of the milk is produced by commercial producers in mixed crop-livestock farms found in the highly productive highlands. These farmers typically keep a herd of between 1 to 4 cross-bred animals under a zero-grazing system. These cows yield an average of 1250 litres/year. The remaining 70% or so of the milk is produced in the lowlands under agro-pastoral management, mostly by pre-commercial producers. These livestock keepers have quite large herds, with the local zebu cows yielding an average of 400 litres/year.

The environment agenda

Livestock production is a key driver of environmental change. Demand increases run the risk of unsustainable livestock production, particularly as many ecosystems in the region are already under heavy pressure. Key environmental footprints of concern include greenhouse gas (GHG) emissions, nutrient mining, food-feed competition, increased water use, and land-use conversion.

Under present production scenarios, dairy production in the Tanga region is currently estimated to emit more than 400,000 tonnes of CO2-equivalent (CO2-e). Of the total emissions (currently at +/- 3 kg CO2-equivalent/kg Fat-Protein Corrected Milk), 83% is estimated to come from enteric fermentation. As the agro-pastoral livestock production system exhibits a much lower animal – and to a lower extent, land – productivity than the zero-grazing system, its emission intensity is about 45% higher than in the mixed system.

Due to sub-optimal manure management, limited fertilizer application and redirecting manure produced by livestock to food crop production, considerable nutrient mining can be observed in the feed producing areas in the mixed crop-livestock systems.

Feed production accounts for most of the water use in dairy production in the district, in the form of evapotranspiration during crop growth. Currently, the feed basket is mostly composed of relatively low-productivity rainfed crops and natural vegetation. Improved crop yields and increased production of high-quality forage would help improve the efficiency of the entire dairy production system, with reduced relative water resource use.

Biodiversity, assessed as the number of endangered species from the IUCN red list, is highest in the native forests that host up to 130 species. No endangered species make use of cropland. Therefore, any forest encroachment for increased feed and fodder production will have a negative impact on biodiversity.

In view of these already considerable pressures on the environment, efforts to maximize milk yields, production and profitability need to be balanced with long-term sustainability and wise environmental stewardship. It is therefore important to assess the potential environmental impacts before embarking on large-scale development projects targeting intensification of livestock production and value chain transformation.

The assessment process

IN 2014 and 2015, the CLEANED approach and tool was used to undertake a comprehensive environmental of the dairy value chain in Tanga.

The process started off with a participatory GIS workshop in June 2014. Stakeholders identified and described the current livestock production systems in the district. They also indicated the spatial distribution of current livestock production systems as well as the likely location of land use change (if any) to support future production-enhancing intervention scenarios.

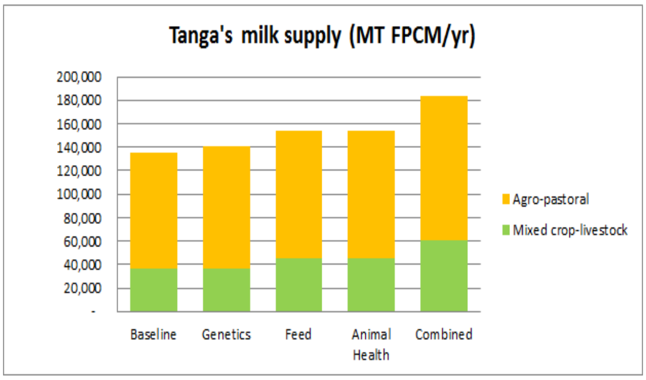
Based on the data gathered during the workshop and existing secondary data, the CLEANED(X) and CLEANED(R) tools were applied to assess the potential environmental impacts of four production-enhancing intervention scenarios on the agro-pastoral and mixed crop-livestock production systems. The four scenarios – (i) introduction of improved breeds, (ii) reduced seasonality of feed availability (iii) improved animal health, and (iv) all three technology interventions packaged together – were based on intervention plans already identified by the Maziwa Zaidi program.

The assessments looked at these interventions in terms of their potential impact on (i) productivity and total milk supply, (ii) mitigation potential in terms GHG emission changes, (iii) changes in area needed for feed production, (iv) changes in water demand relative to water availability, and (v) the impact on soil health in terms of changes in erosion rates and nutrient balances. Assuming an adoption rate of 20%, the overall impact of these productivity-enhancing scenarios on environmental indicators was calculated.

Results of the assessment

Figure 1 shows results in terms of the potential of the four interventions to increase milk supply to meet unmet demand.

Figure 1. Milk production for the baseline and four intervention scenarios for agro-pastoral and mixed crop-livestock production systems in Tanga district: (i) introduction of improved breeds, (ii) reduced seasonality of feed availability (iii) improved animal health, (iv) all three combined.



Figures 2 and 3 show projected changes in land use conversion for the four interventions.

Figure 2. Land requirements for feed production under the baseline and four intervention scenarios for agro-pastoral and mixed crop-livestock production systems in Tanga.

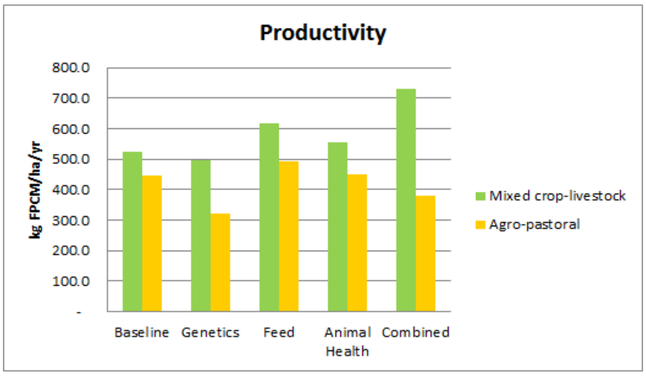
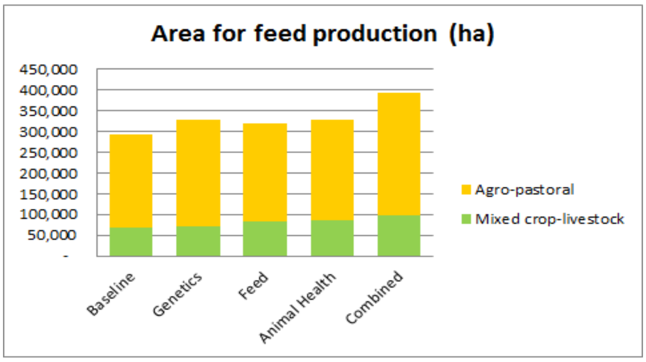


Figure 3. Productivity estimates for the baseline and four intervention scenarios for agro-pastoral and mixed crop-livestock production systems in Tanga



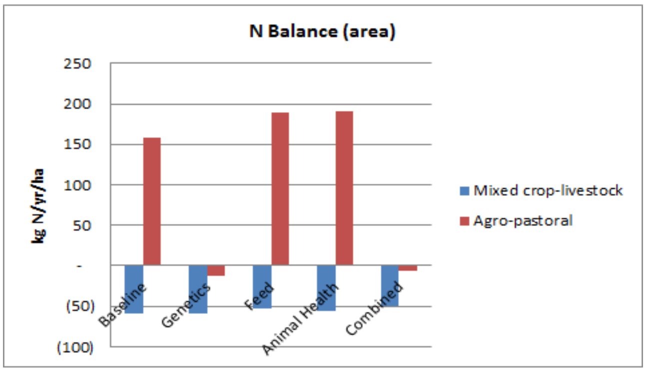
The milk production increase is projected to correlate with increases in land used for feed production, in all scenarios and in both the agro-pastoral and crop-livestock systems. If feed crops replace food crop production, this might mean trade-offs in terms of overall food self-sufficiency.

If non-agricultural land is converted for feed production, negative impacts on biodiversity can be expected. Expansion is especially problematic for endangered species when cropland for feed production is converted from forest. The forests in Tanga are found in the highlands. As such, expansion of cropland in the agro-pastoral system – which is mostly active in the lowlands – is likely to have less impact on biodiversity than changes made in crop-livestock systems in the highlands.

If the stakeholder-defined area for feed expansion would indeed be converted to improved fodder, the species richness index in the converted land would be reduced because endangered species do not make use of cropland. In addition, up to 14 species would be critically affected. If the area were moved slightly north, the highest impact area could be avoided, reducing this impact to up to 8 species affected.

Figure 4 maps changes in water use in the feeds scenario (reduced seasonality of feed availability).

Figure 4. Estimated water use reduction (%) under the feeds scenario.



Water use in dairy production is mostly driven by feed production, which currently comes from low-yielding crops and natural vegetation. Current dairy production uses 10 - 50% of the available rainfall depending on location, with highest intensity use in the croplands.

Water use is calculated as the water evapotranspired by the portion of the crops that is used for feed and fodder. The assessment suggests that the animal health scenario, which – through changes in herd composition – increases the number and productivity of the dairy animals by about 50% without altering the feed base, could double water use. This would have severe consequences for competition from other water users.

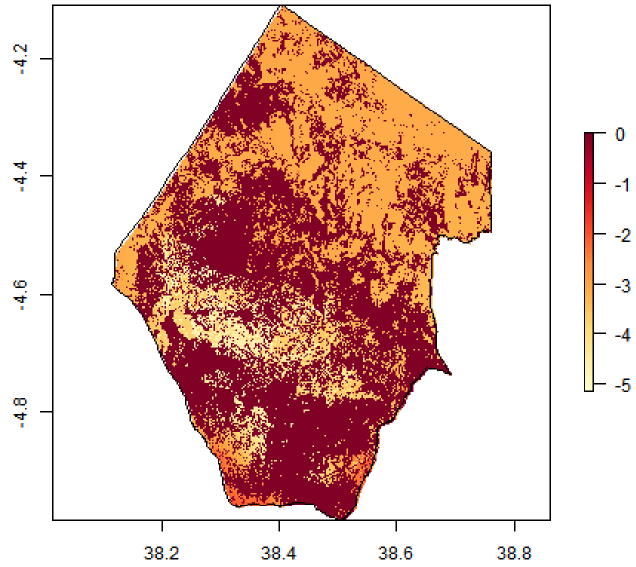
The feed scenario, which features a moderate shift from maize residues and natural vegetation to higher-yielding planted fodder shows a reduction in water use as a result of increased water use efficiency of the feeds produced. This suggests it is possible to increase the dairy herd size and productivity with moderate impact on water use only if feed production becomes more efficient, e.g. through planting fodder such as Napier or Brachiaria grass. However, assuming no conversion of other land to cropland, fodder production comes at the expense of reduced availability of food crops for human use (e.g. maize), which might threaten local food self-sufficiency.

Figure 5 shows changes in the N balance per hectare of feed production for the four interventions.

In the agro-pastoral systems, the impact on the N balance per hectare of feed production would be variable, with N losses only under the genetics and packaged technology scenarios. A significant positive impact on the N balance is projected to happen under the feeds and animal health scenarios, both in absolute and efficiency terms.

In the mixed crop-livestock farms, all envisioned intervention scenarios – apart from genetic improvement – would have a positive impact on efficiency, i.e. result in lower N losses per area or kg milk (FPCM).

Figure 5. N Balance estimates for the baseline and four intervention scenarios for agro-pastoral and mixed crop-livestock production systems in Tanga.

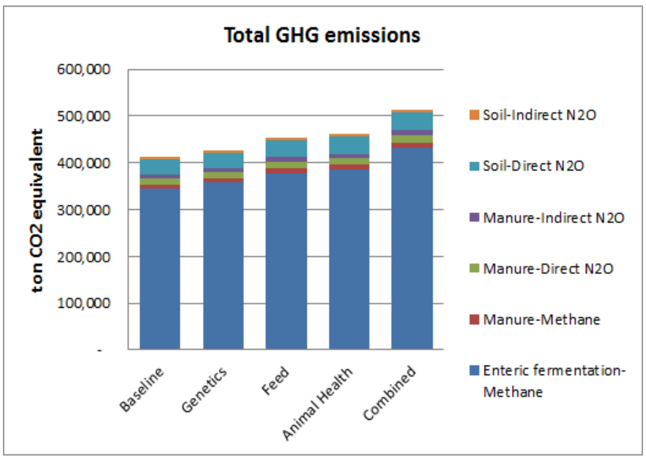


Due to the increased production and larger area used for feed production, overall nutrient mining associated with dairy production in the mixed crop-livestock systems is, however, projected to go up. In these systems, it is thus important to re-direct some of the manure to feed crops for increased long-term sustainability and resilience.

Figures 6 and 7 shows GHG emission estimates for the baseline and four intervention scenarios, in terms of emission types and by production systems.

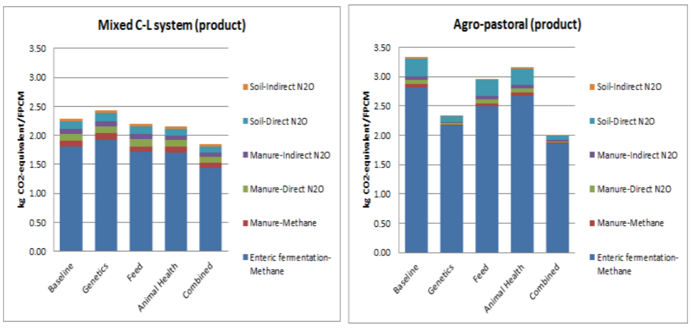
In all intervention scenarios, apart from improved genetics in the agro-pastoral systems, increased milk production and supply correlates to larger herd sizes. At the same time, the animals in these herds are larger and are producing more milk and thus causing higher GHG emissions.

Figure 6. GHG emission estimates for the baseline and four intervention scenarios in Tanga district.



In contrast to the generally higher total GHG emissions, lower emission intensity is also apparent. Due to the current low productivity of the agro-pastoral dairy herds, the assessment suggests that the highest gains in efficiency in combination with relatively low increases in total GHG emissions can be made in these types of enterprises.

Figure 7. GHG emission intensity estimates for the baseline and four intervention scenarios for the agro-pastoral and mixed crop-livestock production systems in the Tanga region.



Discussion and significance

The CLEANED tools used are based on simplified representations of stocks and flows in the two livestock production systems and they allow for quick assessment combining secondary data with local knowledge. They do not yield accurate absolute environmental measures. They are mostly suitable to: (i) compare relative changes, (ii) highlight synergies and trade-offs, and (iii) rank different options.

The most optimal use of these tools is therefore in a multi-stakeholder learning space where people develop participatory development plans. These learning spaces also create opportunities to assess these options in light of cost-benefits that matter to the local communities, in ways that integrate equity concerns, and enabling more informed and inclusive negotiations on potential trade-offs. The application of the framework has identified win-win solutions, such as the shift towards planted fodder, but also trade-offs, such as on biodiversity or food production loss resulting from land conversion. It is able to quantify and visualize impacts, helping decision-makers compare different options.

Conclusions

- Increasing livestock production, without changed system efficiency, normally leads to an increasing environmental footprint, with more animals consuming more resources. In low productivity systems however, appropriate management can mitigate those impacts so the pressure on resources per unit of livestock product can be lower than today. Such productivity gains result from assigning resources more efficiently.
- Greenhouse gas emissions will increase as animal populations increase. This assessment show that, per litre of milk, greenhouse gas emissions can be reduced. The most promising interventions to reach this objective depend on the targeted livestock production system. The highest gains in GHG emission intensity seem to be reached by adopting cross breeds in the agro-pastoral systems, especially if combined with improved feeding strategies and animal health care.
- Nutrient mining, on the other hand, is likely to increase in all scenarios. This is because most of the manure is allocated to cash crops or the main cereals and not to feed and fodder crops, which inevitably leads to a negative nutrient balance. Allocating manure to feed and fodder as well as supplementing soils with other fertilizers is critical to maintain soil health.
- As milk productivity increases, so do energy requirements per animal, leading to increased pressure on water. This impact can be reduced if there is a shift in the feed basket towards higher yielding and more water-efficient planted fodder. This provides more feed for the same amount of water. However, this gain might be at the cost of food self-sufficiency if the planted fodder replaces maize or other food crops.
- Allocating more land to feed and fodder production often causes land cover changes that reduce the habitat of endangered species. However, some land cover conversions are more critical to those species than others. Highest losses are expected when converting natural forests to cropland. Therefore policies should protect sensitive areas. Spatial planning can help minimize biodiversity loss.

Credits and more information

This brief was produced as part of a synthesis activity of the CGIAR Research Program on Livestock and Fish. It focuses on ex-ante environment impact assessment work carried out between 2012 and 2
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